Chemistry 181H

Fall, 2oo8

EXAM I

Thursday, 25 Sept 2oo8

WRITE your Name _____

Student Number _____

Recitation Time: Monday _____

There are 7 questions on this exam, worth 15 points each.

Write your answer, showing all work to each on each page.

A list of potentially useful equations is on page 9.

A periodic table is contained on page 10.

#	Score
1	/15
2	/15
3	/15
4	/15
5	/15
6	/15
7	/15
total	/100

1. Uranium is the heaviest element found on earth. All the isotopes of uranium are radioactive and only the two long-lived isotopes, 235 (235.046 g/mol) and 238 (238.051 g/mol), have survived since the supernova that created them. The lighter isotope is used to create energy through fission but it is relatively rare. Nuclear engineers use the difference of gaseous velocities in centrifuges to remove some of the heavier isotope from the natural mixture to create "enriched" uranium for nuclear fuel. The separation is difficult due to the very small amount of ^{235}U and the small difference between the masses of the isotopes. The other product from the separation process is called "depleted" uranium and is used in bullets and armor due to its high density (19.1 grams/cm^3).

   (a) (5 points) Estimate the fractional abundance of the lighter uranium isotope in nature.

   (b) (5 points) Gaseous separation uses uranium hexafluoride (UF_6) because it is the lightest known gas that contains uranium. There are only two isotopic forms of UF_6 because fluorine is monoisotopic. Calculate the masses of these two molecules.

   (c) (5 points) What is the volume of a 10 gram bullet made out of depleted uranium?

2. The following questions on this page refer to the interactions between carbon and oxygen atoms versus nitrogen and oxygen atoms. Both carbon and nitrogen form a monoxide.

Element	C	N	O	
Melting point	3825	63.05	54.8	K
First Ionization Potential	1090	1400	1310	kJ/mol
$\chi_{Pauling}$	2.6	3.0	3.4	
Electron Affinity	122	-7	141	kJ/mol
Atomic Radii	77	74	66	pm

(a) (5 points) Give a concise explanation of why NO is reactive and forms a dimer whereas CO is much more inert does not dimerize.

(b) (5 points) Concisely explain what feature of the Lewis structure of CO, a colorless molecular gas at room temperature, is problematic because it is counter to our understanding of ionic compounds?

(c) (5 points) Compare the percent ionic character of the NO molecule to that of the CO molecule.

3. The following questions on this page will require some of the information in the table below.

Element	K	Cl	
Melting point	336.5	171.6	K
First Ionization Potential	418	1255	kJ/mol
$\chi_{Pauling}$	0.82	3.2	
Electron Affinity	-48	-349	kJ/mol
Ionic Radii	138	181	pm

(a) (10 points) Use some of the information in following table to make an estimate of the Coulomb potential of a KCl ion pair at their equilibrium separation.

(b) (5 points) KCl forms the same lattice type as NaCl and has a Madelung constant of 1.748 The Madelung constant can be viewed as a correction factor, what does this factor correct for?

4. Give the Lewis structure, the name of the VSEPR 3D molecular structure, and the bond angle for the following molecules or molecular ions.

   (a) (3 points) ozone molecule (O_3)

   (b) (3 points) phosphite anion (PO_2^-)

   (c) (3 points) formate anion (HCO_2^-)

   (d) (6 points) fluoro-hypochlorite molecule (FClO)

5. Give the Lewis structure, the name of the VSEPR 3D molecular structure, and the bond angles at the specified atom in the following molecules or molecular ions.

   (a) (3 points) the nitrogen atom in (NO_2)

   (b) (3 points) the carbon atom in thioformaldehyde (SCH_2)

   (c) (3 points) xenon atom in xenon oxy-difluoride ($XeOF_2$)

   (d) (6 points) The compound N_2O_3 was shown in lecture to have two isomeric forms. Clearly explain what is meant by "isomer forms" in words or Lewis diagrams.

6. Two questions on cell phones electromagnetic radiation.

   (a) (5 points) Most cell phones can operate at two or three radio frequencies. Calculate the wavelength of the radiation emitted by a iPhone operating at 850 MHz.

   (b) (10 points) Estimate the number of photons emitted in one second by an iPhone 3G cell phone that is operating a frequency of 1.9 GHz with a power of 20 milliwatts.

7. Answer the following three questions based on Bohr's atomic model:

   (a) (5 points) Concisely describe the key assumption that Bohr made that lead to his successful description of atomic line spectra.

   (b) (5 points) What does this model predict for the total energy of the lowest state in a Be^{3+} ion?

   (c) (5 points) What does this model predict for the smallest radius of a Be^{3+} ion?

Potentially Useful Constants 17 Sept 08

$R = 0.08206\ \ell$ atm $^\circ K^{-1}$ mole^{-1} $\qquad$ $R = 8.314$ J $^\circ K^{-1}$ mole^{-1}

$k_B = R/N_A = 1.38066 \text{x} 10^{-23}$J $^\circ K^{-1}$ $\qquad$ 1. amu = 1.6605 x 10^{-27} kg

h = 6.626 x 10^{-34} J sec $\qquad$ c = 2.99792 x 10^8 m sec^{-1}

$N_A = 6.0221$ x 10^{23} mole^{-1} $\qquad$ $\epsilon_0 = 8.8542$ x 10^{-12} Coulomb^2 J^{-1} m^{-1}

proton mass = 1.67263 x 10^{-27} kg $\qquad$ electron mass = 9.1094 x 10^{-31} kg

neutron mass = 1.67493 x 10^{-27} kg $\qquad$ electron charge = 1.60218 x 10^{-19} Coul

$c_1 = 56.705\ nWm^{-2}K^{-4}$ $\qquad$ $c_2 = 1.44\ cm\ K$

$a_0 = \epsilon_0 h^2/e^2 \pi m_e = 52.92$ pm $\qquad$ $R_H = 109,737$ cm^{-1}

$r = 1.2$ fm $A^{1/3}$ $\qquad$ $V_{sphere} = 4\pi\ r^3/3$ $\qquad$ $A_{sphere} = 4\pi\ r^2$

$F = -\frac{d}{dx}V(x)$ $\qquad$ $E_T = E_K + E_P$ $\qquad$ $F_{coulomb} = q_1 q_2 e^2/4\pi\epsilon_0 r^2$

$V_{coul} = q_1\ q_2\ e^2\ /\ 4\ \pi\epsilon_0\ r$ $\qquad$ $V_{lattice} = N_A\left(q_1\ q_2\ e^2\ /\ 4\ \pi\epsilon_0\ d\right) A$

$p = m\ v$ $\qquad$ $E_K = \frac{1}{2}\ m\ v^2 = p^2/2m$

$\chi_A = (FIP + |EA|)/2$ $\qquad$ $\%\text{-IC} = 16|\chi_A - \chi_B| + 3.5|\chi_A - \chi_B|^2$

$|\chi_A - \chi_B| = 0.102\sqrt{\Delta}$ $\qquad$ $\Delta = BDE(A:B) - \sqrt{BDE(A_2) * BDE(B_2)}$

$FC = (\#Valence\ e^-) - (\#LonePair\ e^-) - \frac{1}{2}(\#Bonding\ e^-)$

$E = h\nu$ $\qquad$ $\lambda\ \nu = c$ $\qquad$ $E = E_0 \sin[(2\pi/\lambda)(x - ct)]$

$P/A = c_1 T^4$ $\qquad$ $T\lambda_{max} = c_2/5$

$\rho(T,\nu) = \left(8\pi h\nu^3/c^3\right)\left(\frac{1}{e^{h\nu/kT}-1}\right) \approx 8\pi k_B T\nu^2/c^3$ $\qquad$ $1/\lambda = R_H\left(1/n_{low}^2 - 1/n_{high}^2\right)$

$E_B(n) = -2.18$ x 10^{-18} J $\frac{1}{n^2}$ $\quad E_B(n,Z) = \frac{-Z^2 e^4 m}{8\epsilon_0^2 h^2}\frac{1}{n^2}$ $\qquad$ $E_B(n,Z) = -13.60\text{eV}\ \frac{Z_{eff}^2}{n^2}$

$\Delta E(n) = 2.18$ x 10^{-18}J $\left(1/n_2^2 - 1/n_1^2\right)$ $\qquad$ $\Delta E(n,Z) = 2.18$ x 10^{-18}J $Z_{eff}^2\ \left(1/n_2^2 - 1/n_1^2\right)$

$r_B(n) = n^2 h^2 \epsilon_0/\pi m e^2 = a_0\ n^2$ $\qquad$ $hcR_H = \frac{e^4 m}{8\epsilon_0^2 h^2} = 2.18$ x 10^{-18}J

	1																	18
1	1 H 1.0079	2											13	14	15	16	17	2 He 4.0026
2	3 Li 6.939	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.183
3	11 Na 22.990	12 Mg 24.312	3	4	5	6	7	8	9	10	11	12	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
4	19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.909	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90	46 Pd 106.4	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
6	55 Cs 132.90	56 Ba 137.34	*	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po (210)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	**	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (265)	109 Mt (268)	110	111	112						

* Lathanides	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
** Actinides	89 Ac (227)	90 Th 232.04	91 Pa 231.03	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)